BEAR Essentials

Overview of the Berkeley Energy and Resource Model

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Objectives

1. Estimate direct and economywide indirect impacts and identify adjustment patterns (BEAR).
2. Inform stakeholders and improve visibility for policy makers.
3. Promote empirical standards for policy research and dialogue.

Why a state model?

1. California needs research capacity to support its own policies
   - A first-tier world economy
2. California is unique
   - Both economic structure and emissions patterns differ from national averages
3. California stakeholders need more accurate information about the adjustment process
   - National assessment masks interstate spillovers and trade-offs

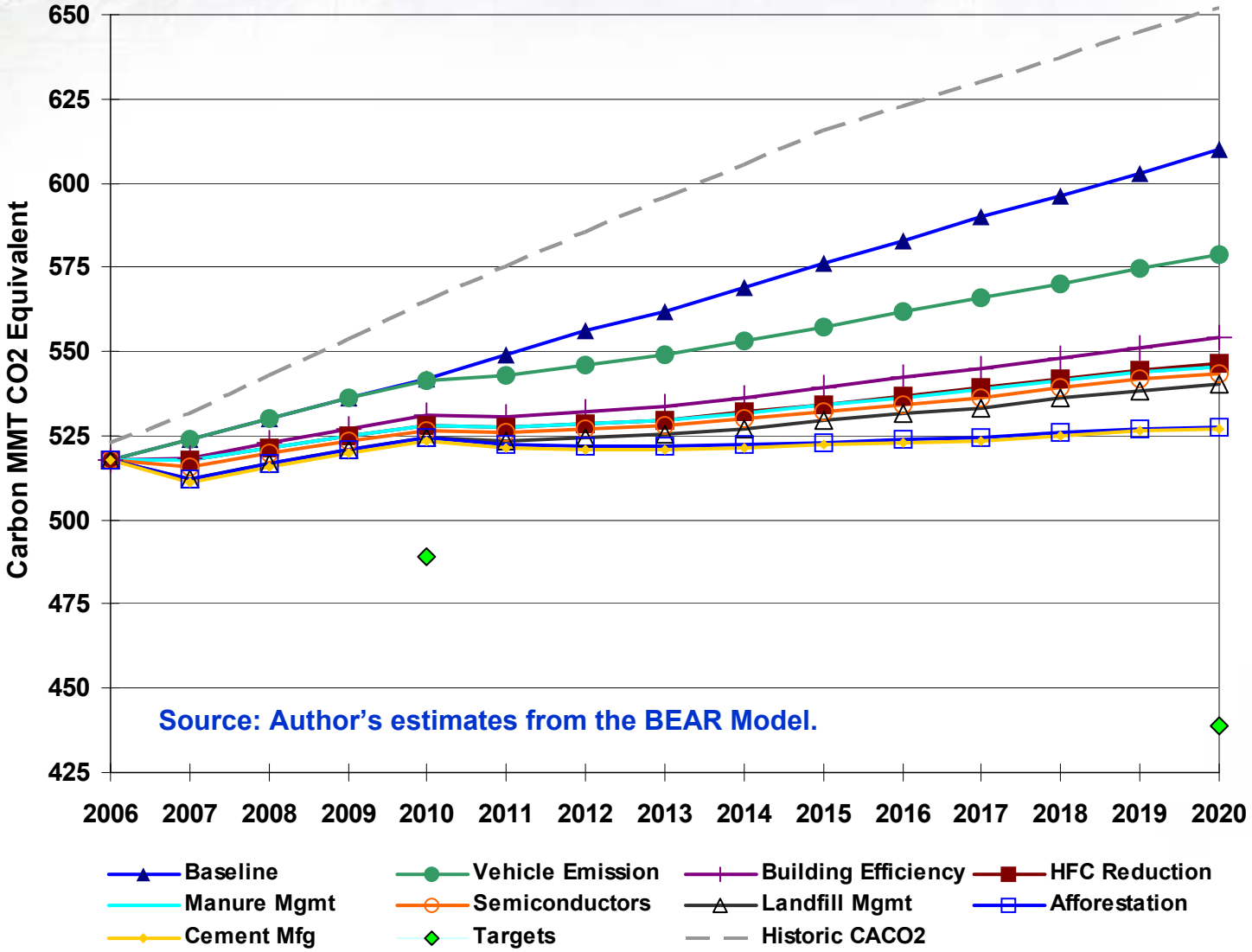
Why a General Equilibrium Model?

1. *Complexity* - Given the complexity of today's economy, policy makers relying on intuition and rules-of-thumb alone are assuming substantial risks.
2. *Linkage* - Indirect effects of policies often outweigh direct effects.
3. *Political sustainability* - Economic policy may be made from the top down, but political consequences are often felt from the bottom up. These models identify stakes and stakeholders *before* policies are implemented.

Prior Research: Climate Action

1. Building Efficiency
2. Vehicle Emission Standards
3. HFC Reduction
4. Manure Management
5. Semiconductors
6. Landfill Management
7. Afforestation
8. Cement Manufacturing

Only Eight Measures Achieve Half of California's GHG Targets



Climate Action with Growth

	GHG MMT	Percent of Goal	GSP Millions	Jobs
2010	-19	-35	4,950	8,340
2020	-83	-49	58,800	20,350

Source: Author's estimates from the BEAR Model.

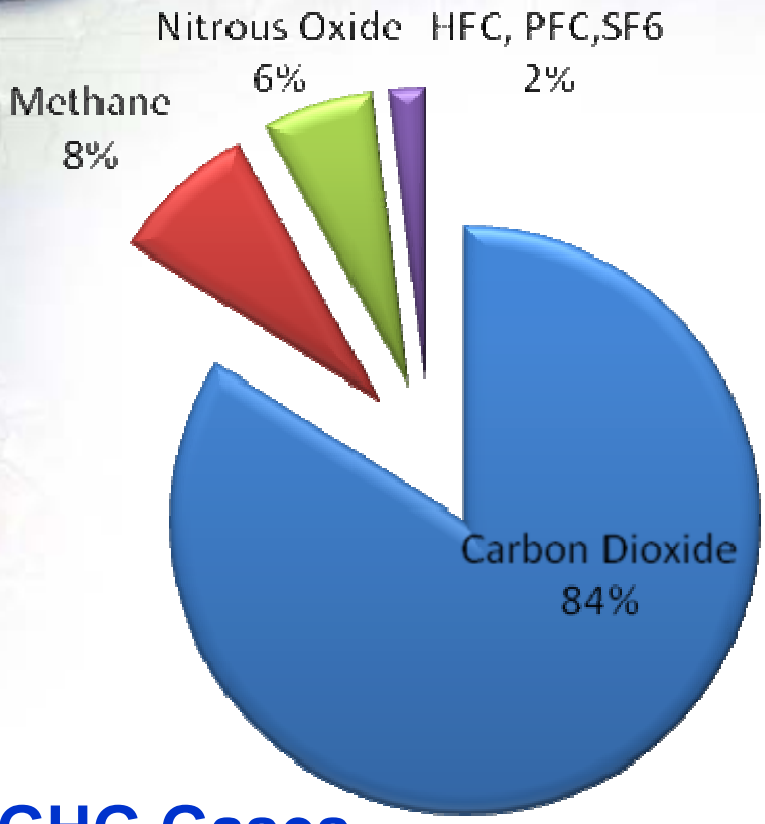
Current Research

Under Energy Foundation sponsorship, BEAR is being applied to AB32.

Two studies:

1. Macro effects
2. Structural adjustment in leading sectors

Climate Change and Carbon Fuel

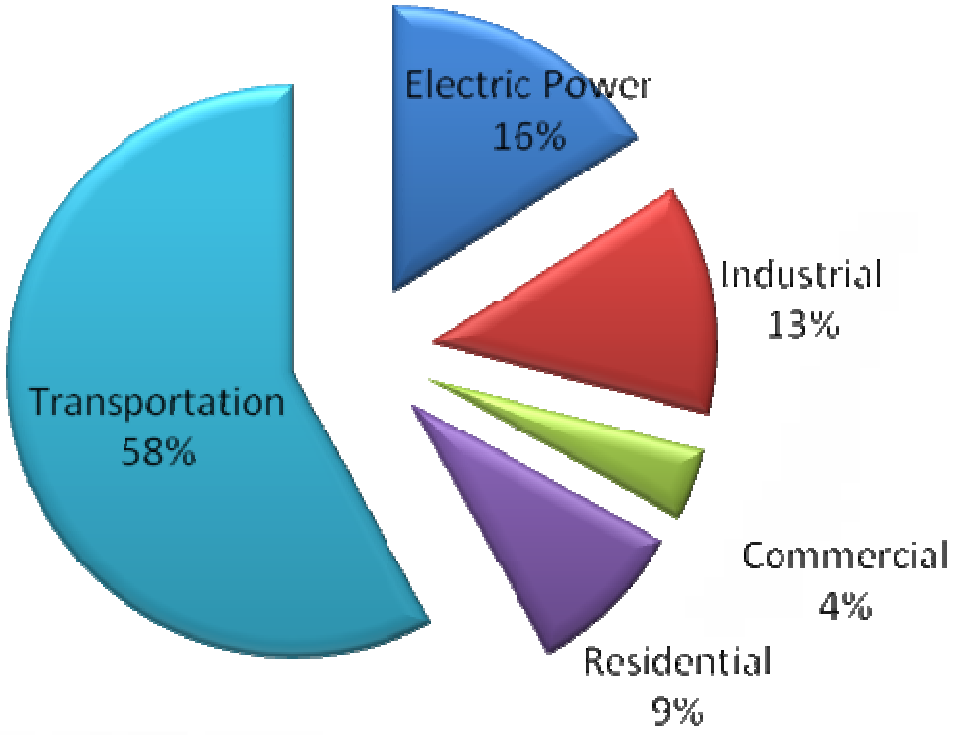


GHG Gases

(CO2 equivalent shares)

Source: CEC

CO2 Sources



AB32

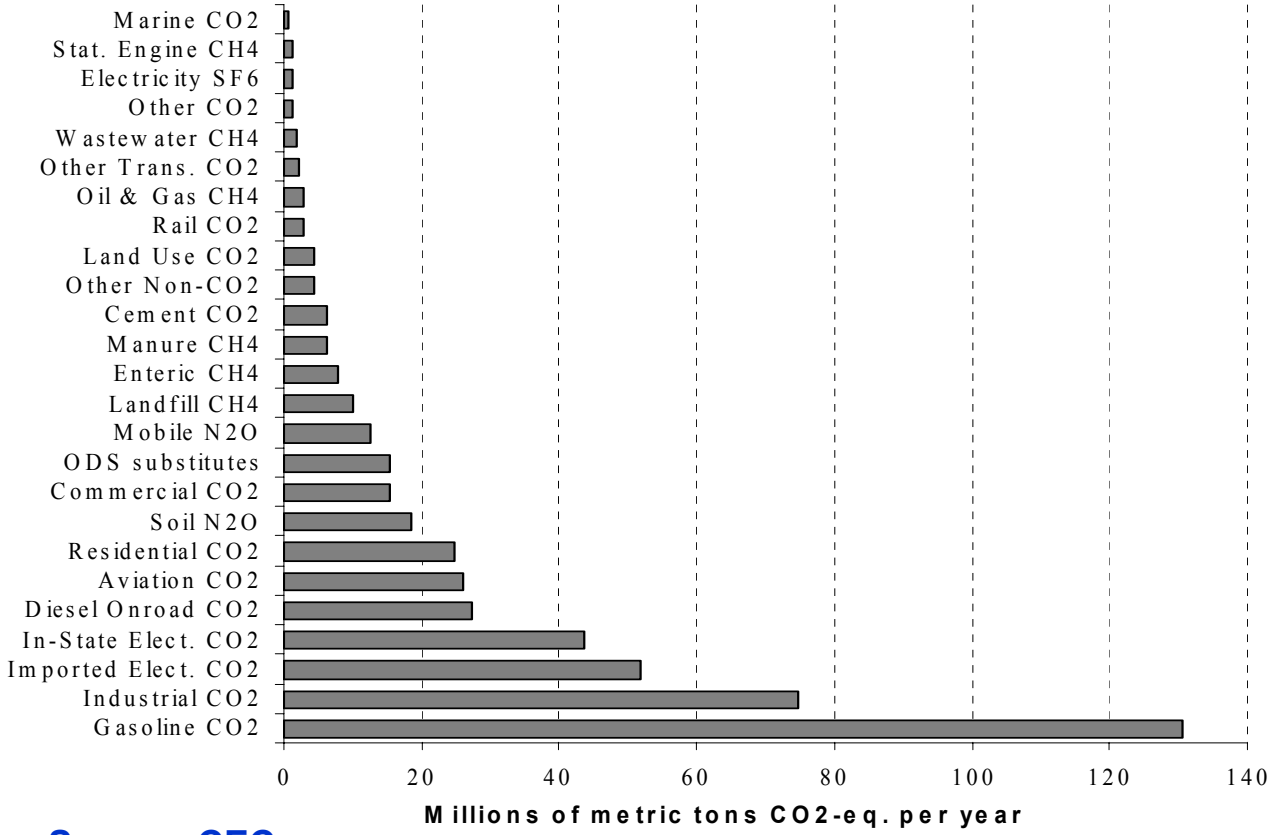
- The "California Global Warming Solutions Act of 2006," is the first law to comprehensively limit greenhouse gas (GHG) emissions at the state level.
- The bill's stated objective is to return GHG emissions to 1990 levels, using some kind of cap and trade mechanism.
- Negotiations on the precise mechanisms will take about two years, but salient features are already discernable.

Cap and Trade Canons

1. **Scope:**
   There are two components to the scope of a cap and trade scheme: Which emissions and which entities are to be covered by the policy.
   The first of these is self-evident, and depends on the target for environmental mitigation (GHG, toxics, particulates, etc.).
   In the second category, there are many practical issues of monitoring, regulation, and incentives. A basic distinction is usually made between upstream (resource oriented), and downstream (end use) entities. For example, to manage carbon emissions, one could regulate fuel producers or consumers.
2. **Allocation:**
   This is the rule by which property rights are assigned. For example, in a cap and trade scheme, emission rights are usually a privately tradable financial asset. How these are allocated policy inception obviously influences private economic behaviour.
3. **Banking:**
   This term refers to the potential for inter-temporal transfer of pollution rights. In an uncertain and cyclical economic environment, banking can improve efficiency.
4. **Safety Valves:**
   These mechanisms permit conditional and temporary flexibility in emission constraints (caps). Understandably, they have complex behavioural properties, including risks of moral hazard and market manipulation, but they can also improve prospects for policy adoption and sustainability.
5. **Linkage:**
   This term refers to interactions between different policies, either in different places or contexts.
6. **Justice:**
   Policies toward the economy and environment can have many welfare implications and should be designed to be equitable.

Scope of Coverage

The focus on stationary sources, and among these more concentrated emitting industries



Source: CEC

Potential Target Sectors

- **Group 1: First Tier Emitters**
  A04DistElc Electricity Suppliers
  A17OilRef Oil and Gas Refineries
  A20Cement

- **Group 2: Second Tier Emitters**
  A01Agric Agriculture
  A12Constr Transport Infrastructure
  A15WoodPlp Wood, Pulp, and Paper
  A18Chemicl Chemicals
  A21Metal Metal Manufacture and Fab.
  A22Aluminm Aluminium Production

- **Group3: Other Industry Emitters**
  A02Cattle Cattle Production
  A03Dairy Dairy Production
  A04Forest Forestry, Fishery, Mining, Quarrying
  A05OilGas Oil and Gas Extraction
  A06OthPrim Other Primary Activities
  A07DistElec Generation and Distribution of Electricity
  A08DistGas Natural Gas Distribution
  A09DistOth Water, Sewage, Steam
  A10ConRes Residential Construction
  A11ConNRes Non-Residential Construction
  A13FoodPrc Food Processing
  A14TxtAprl Textiles and Apparel
  A16PapPrnt Printing and Publishing
  A19Pharma Pharmaceuticals
  A23Machnry General Machinery
  A24AirCon Air Conditioner, Refrigerator, Manufacturing
  A25SemiCon Semiconductors
  A26ElecApp Electrical Appliances
  A27Autos Automobiles and Light Trucks
  A28OthVeh Other Vehicle Manufacturing
  A29AeroMfg Aeroplane and Aerospace Manufacturing
  A30OthInd Other Industry

A Few Scenarios

- Baseline (no emission reduction target) [1]
- 8 CAT policies (direct regulation) [2]

CAT policies plus emission cap to meet remainder of 2020 target

- Industries in Group 1 covered by an aggregate cap [3]
- Industries in Groups 1 and 2 covered by an aggregate cap [4]
- Industries in Groups 1, 2 and 3 covered by an aggregate cap [5]
- CAT policies plus emission cap on industries in Groups 1, 2 and 3 with revenues recycled into innovation investment [6]
- CAT policies plus emission cap on all emitting industries with revenues recycled into innovation investment [7]

Preliminary Results

Scenario	2 CAT	3 Group1	4 Group12	5 Group123	6 G123Gr	7 AllIn
Total GHG*	-13	-28	-28	-28	-28	-28
Household GHG*	-32	-32	-32	-32	-31	-30
Industry GHG*	-3	-26	-26	-26	-26	-27
Annual GSP Growth*	2.4	2.4	2.4	2.4	3.1	4.7
Employment*	.10	.06	.08	.08	.44	1.07

*Percent change from Baseline scenario in the year 2020.

Jobs (thousands)	20	13	16	17	89	219
Percent of GHG Target	47	101	100	100	100	100

Macroeconomic Impacts of 8 CAT policies plus a 2020 GHG Cap

Annual Impact	8 CAT policies + Cap	8 CAT policies + Cap w/Innovation Incentives
Gross State Product (2006 dollars) *% change from 2020 baseline*	**+$60 Billion** *(+2.4%)*	**+$74 Billion** *(+3.1%)*
Employment (thousands) *% change from 2020 baseline*	**+17** *(+.08%)*	**+89** *(+0.44%)*

Annual Emission Reductions

Scenario	2	3	4	5	6	7
Sector	CAT	Group1	Group12	Group123	G123Gr	AllIn
A01Agric	.00	-.01	-3.64	-2.95	-2.94	-2.36
A02Cattle	.00	-.01	-.01	-2.95	-2.95	-2.37
A03Dairy	-.47	-.48	-.48	-3.16	-3.15	-2.60
A04Forest	.00	-.01	-.01	-2.95	-2.93	-2.27
A05OilGas	.00	-.03	-.01	-2.96	-2.93	-2.30
A06OthPrim	.00	-.01	-.01	-2.96	-2.90	-2.50
A07DistElec	.00	-4.40	-3.61	-2.93	-2.97	-2.42
A08DistGas	.00	-.01	.00	-2.95	-3.00	-2.52
A09DistOth	.00	-.01	-.01	-2.96	-2.89	-2.21
A10ConRes	.00	-.01	.00	-2.95	-2.85	-2.28
A11ConNRes	.00	.00	.00	-2.95	-2.87	-2.24
A12Constr	.00	-.01	-3.65	-2.96	-2.86	-2.35
A13FoodPrc	.00	-.01	.00	-2.96	-3.00	-2.54
A14TxtAprl	.00	-.01	.00	-2.95	-2.90	-2.48
A15WoodPlp	.00	-.01	-3.65	-2.96	-2.85	-2.17
A16PapPrnt	.00	-.01	.00	-2.95	-2.93	-2.44
A17OilRef	.00	-4.35	-3.58	-2.90	-2.92	-2.34
A18Chemicl	.00	-.01	-3.65	-2.95	-2.91	-2.30
A19Pharma	.00	-.01	.00	-2.95	-2.95	-2.41
A20Cement	-.35	-4.54	-3.78	-3.13	-3.09	-2.60
A21Metal	.00	-.01	-3.65	-2.96	-2.80	-2.08
A22Aluminm	.00	-.01	-3.65	-2.96	-2.82	-2.16
A23Machnry	.00	-.01	.00	-2.95	-2.90	-2.48
A24AirCon	-4.74	-4.74	-4.74	-5.65	-5.62	-5.45
A25SemiCon	-4.44	-4.45	-4.45	-5.47	-5.45	-5.29
A26ElecApp	.00	.00	.00	-2.95	-2.98	-2.82
A27Autos	.00	.00	.00	-2.95	-2.99	-2.73
A28OthVeh	.00	-.01	.00	-2.95	-2.87	-2.32
A29AeroMfg	.00	.00	.00	-2.95	-2.95	-2.70
A30OthInd	.00	-.01	.00	-2.95	-2.87	-2.32

Preliminary Conclusions

- California's GHG targets are attainable, but too ambitious to be met by voluntary initiative. Policy action to meet the targets should be relatively inclusive, with mandatory participation by all sectors representing a significant share of emissions.
- An Emissions Cap, supported by regulatory and market-based implementation programs, can return California's GHG emissions to 1990 levels by 2020 and stimulate the state economy.
- Climate policies that create direct incentives for industries to invest in new technologies can provide additional stimulus for new employment and growth.

Three Economic Principles

1. Demand Shifting: New demand for California goods and services.
2. Benefits Exceed Costs: Direct adjustment costs for some stakeholders, but these are outweighed by indirect statewide benefits.
3. Early Action Pays: Conversion costs are fixed, but efficiency benefits compound like interest.

Innovation, Efficiency, Growth

The Growth-Environment tradeoff is a fallacy, and in California we can prove this.

- California is the world's premiere innovation economy.
- Efficiency is a potent stimulus for economic growth.
- Energy, transportation, and others can join IT, Biotech, and California's knowledge-intensive state industries to establish global standards for more sustainable economic growth.

Extensions

- More detailed industry and adjustment modeling
- Mechanism Design: Testing revenue recycling, incentives, etc.
- Mobile sources: too important to omit?
- Whither Prometheus? Endogenous innovation in a world of carbon markets
- Location/GIS

BEAR Modeling Facility

The modeling facility stands on two legs:

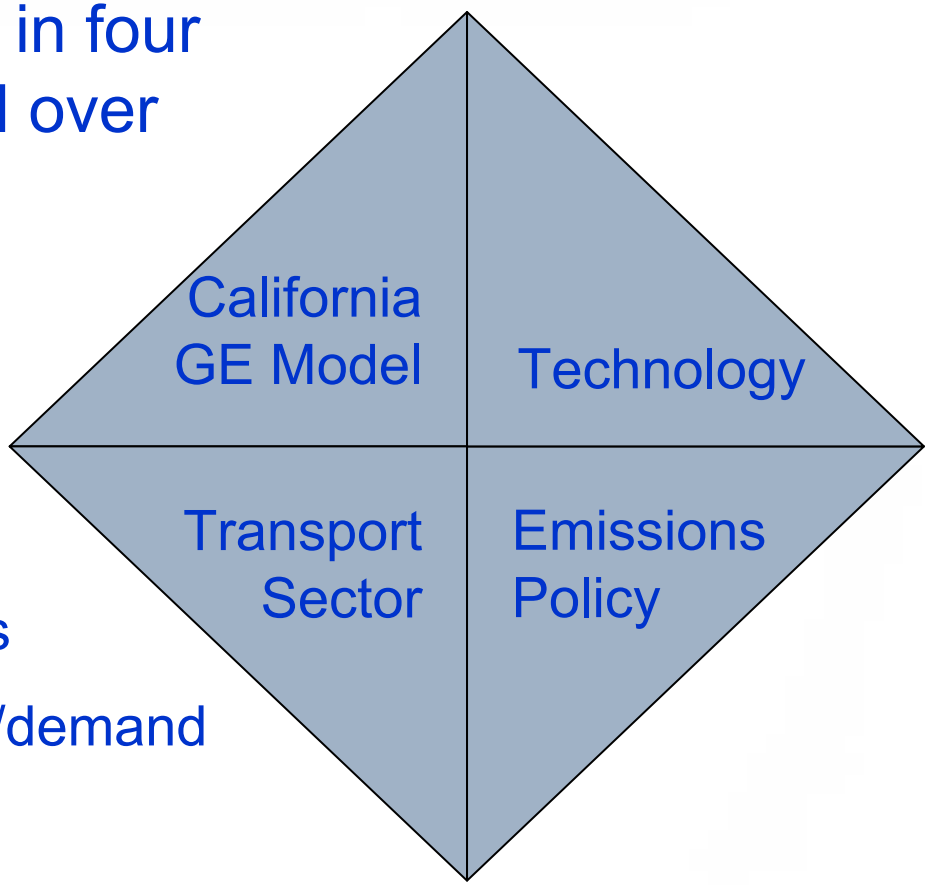
1. Detailed economic and emissions data
    1. 2004 California SAM, 120/165 sectors
    2. IPPS and CA emissions data
2. An intertemporal GE forecasting model

Schematic Structure

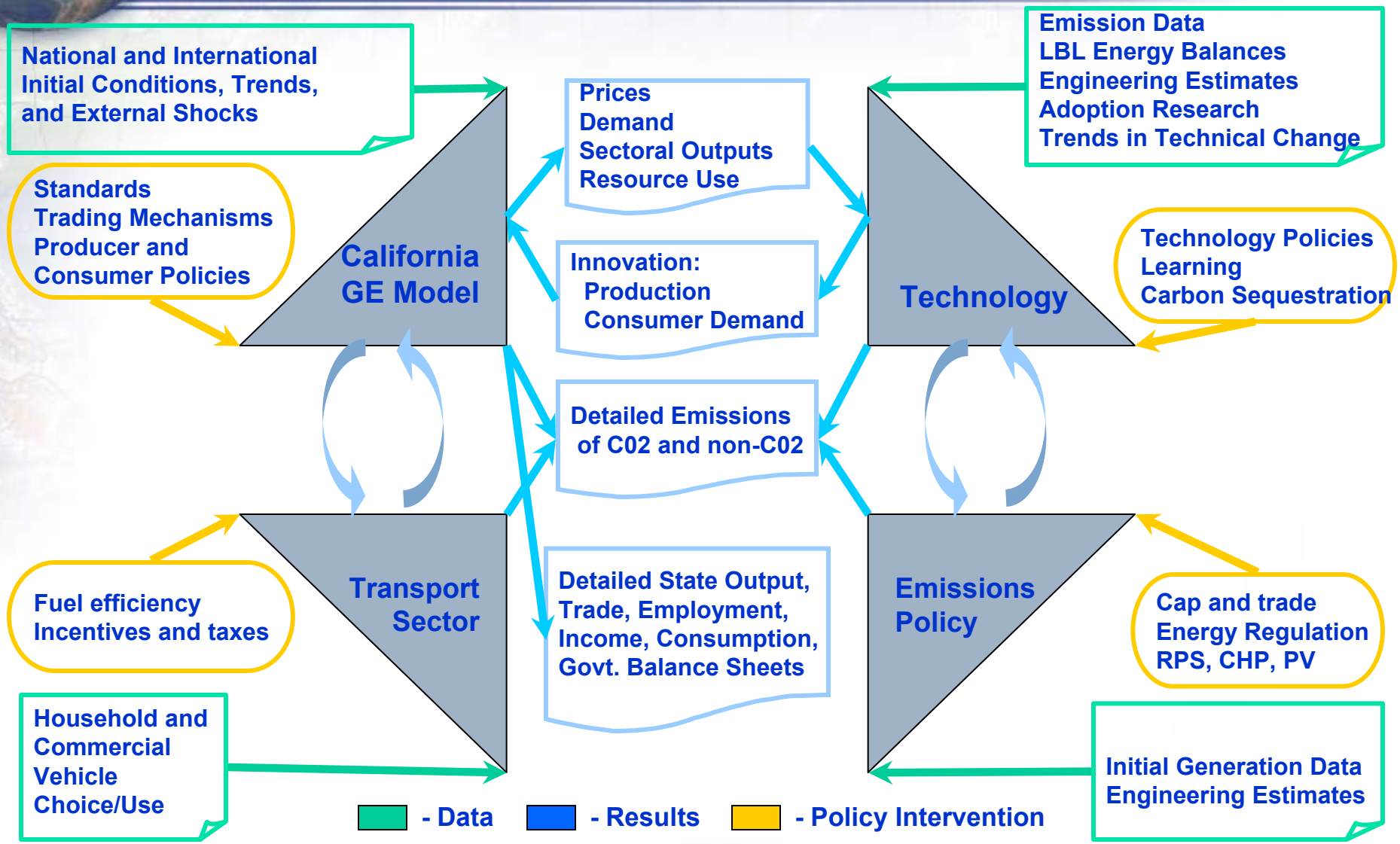
BEAR is being developed in four areas and implemented over two time horizons.

Components:

1. Core GE model
2. Technology module
3. Emissions Policy Analysis
4. Transportation services/demand



Detailed Structure



Time Horizons

BEAR is being developed for scenario analysis over two time horizons:

1. **Policy horizon**: 2005-2025

   Detailed structural change:

   1. 120/165 sectors
   2. 10 household income groups
   3. Labor by occupation, land, and capital by vintage

2. **Climate horizon**: 2005-2100

   Aggregated:

   1. 10 sectors
   2. 3 income groups
   3. labor, land, and capital

Intertemporal Issues

- Population growth is exogenous, the California labor market is open.
- Capital stock is driven by past investments and depreciation.
- Total factor productivity is calibrated in baseline to achieve a GDP growth target.

Emissions

Emissions are modeled as a composite of pollution in use and in process

1. *Pollution in Use* arises from per unit, intermediate and final consumption of goods and services
2. *Pollution in Process* is residual pollution, ascribed to production on a per unit of output basis

Non-CO2 Emission Categories

Air	1 Suspended particulates 2 Sulfur dioxide (SO2) 3 Nitrogen dioxide (NO2) 4 Volatile organic compounds 5 Carbon monoxide (CO) 6 Toxic air index 7 Biological air index
water	8 Biochemical oxygen demand 9 Total suspended solids 10 Toxic water index 11 Biological water index
Land	12 Toxic land index 13 Biological land index

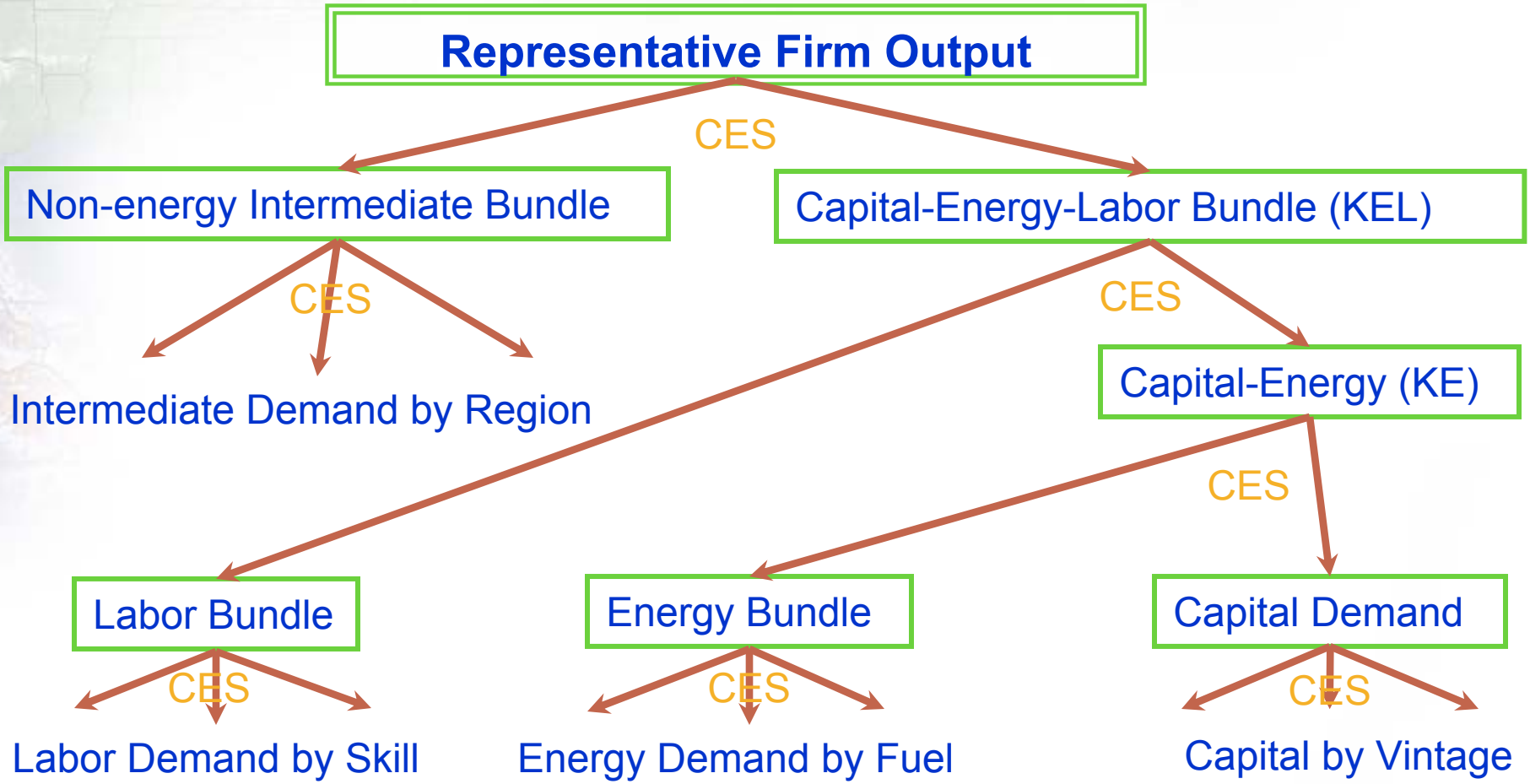
Technology

- Technology and adoption behavior are the primary determinants of resource use patterns
- Future versions of the model will incorporate endogenous technological change and learning
- Production and consumption technology are currently being studied in three contexts each

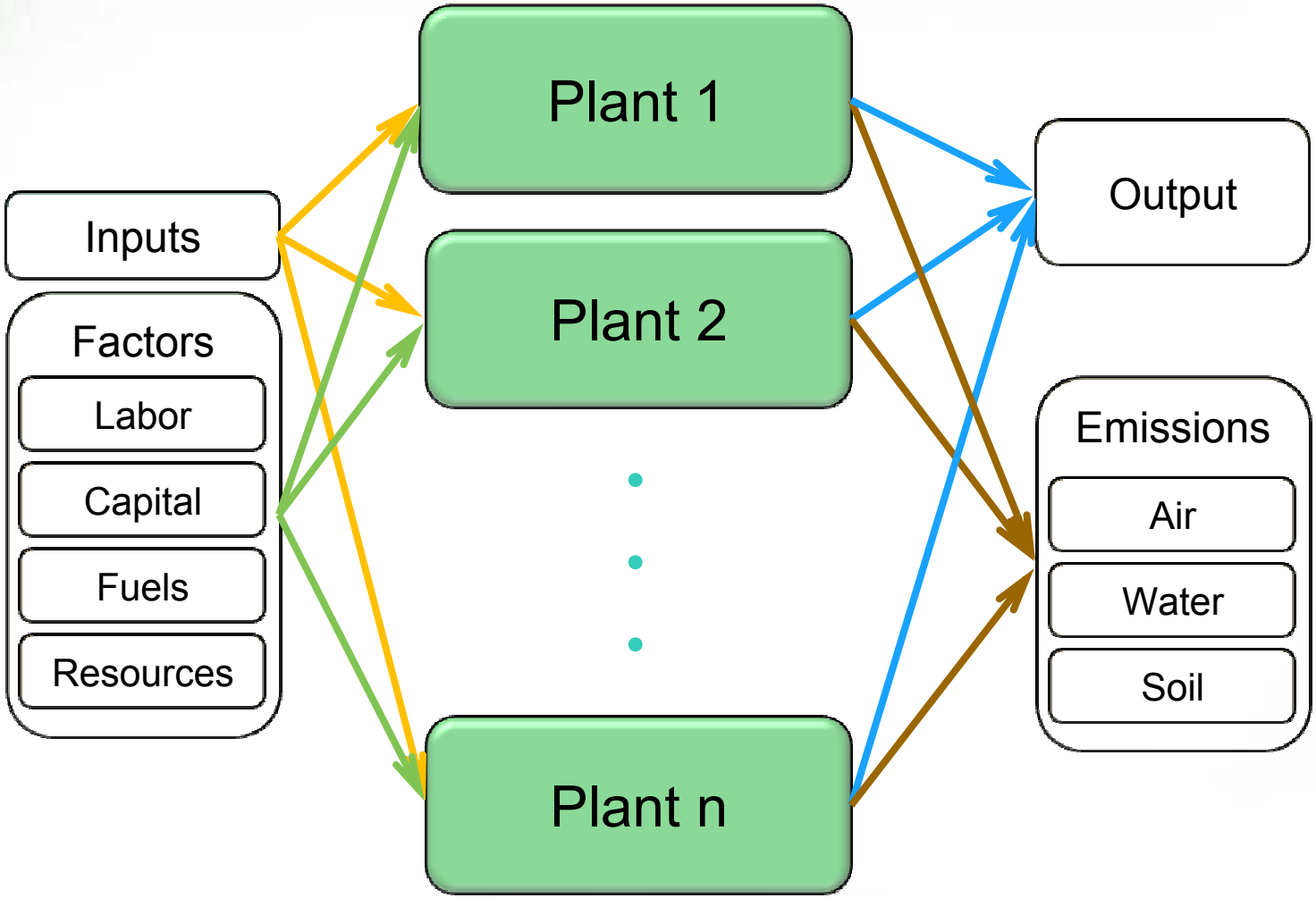
Areas of Research Emphasis

- Supply Side - Technology
  - Oil Refining
  - Cement
  - Electric Power
- Demand Side – Adoption behavior
  - Transport services
  - Appliances
  - Building standards

Generic Production Structure



Oil Refining and Cement



Electric Power

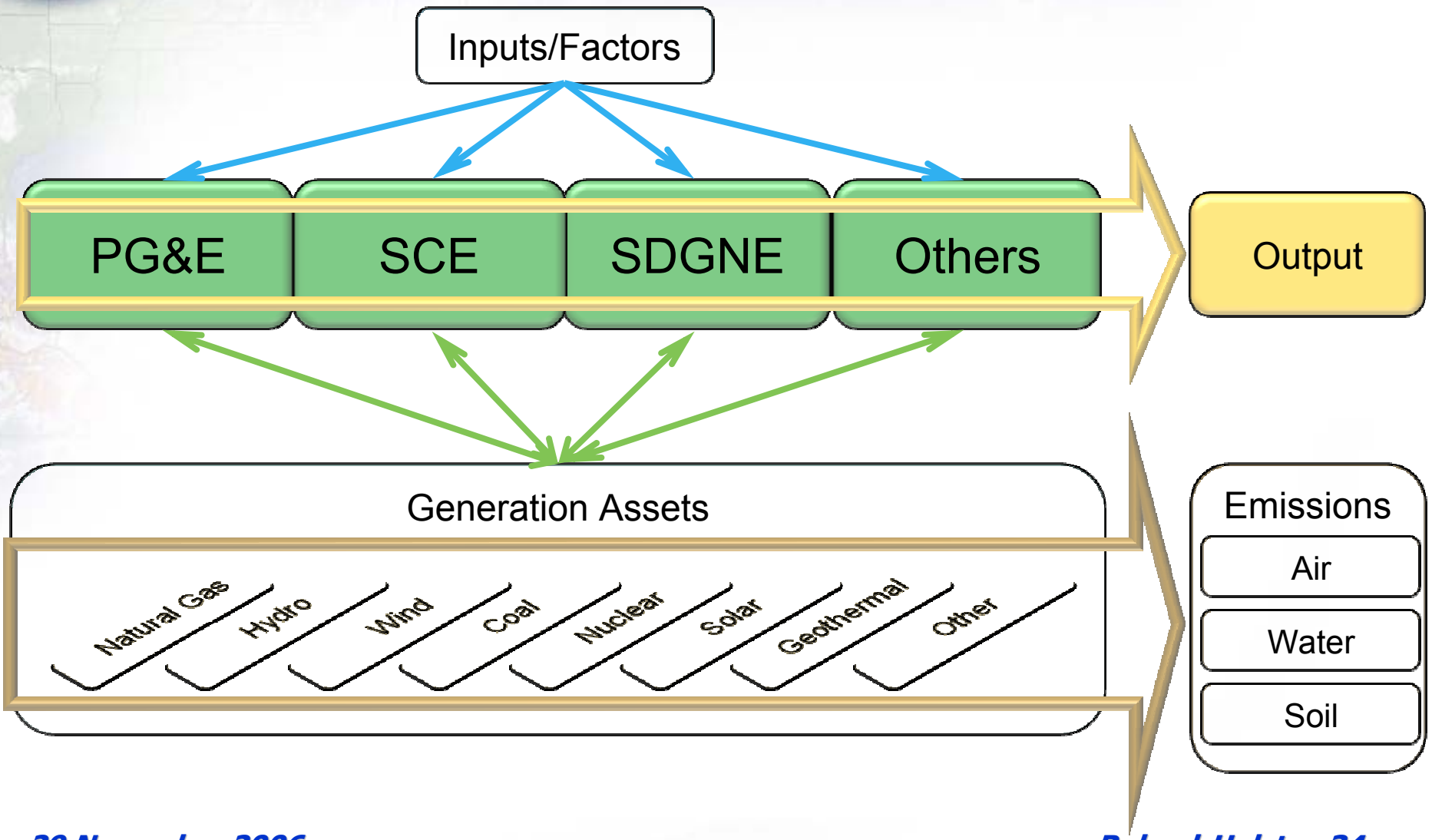
Distinctive features:

1. A portfolio of production technologies
2. Rigid output prices
3. Excess capacity

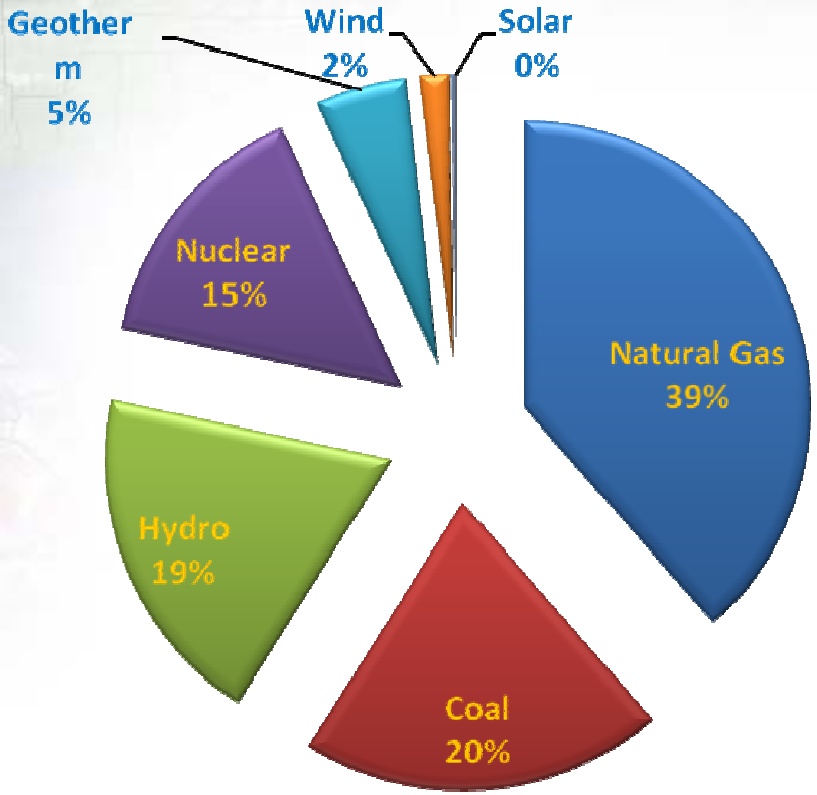
Modeling strategy:

1. Fixed price, demand-driven market
2. Producers choose:
    1. Short run: capacity utilization rate
    2. Long run: Capacity (contracts, investment)

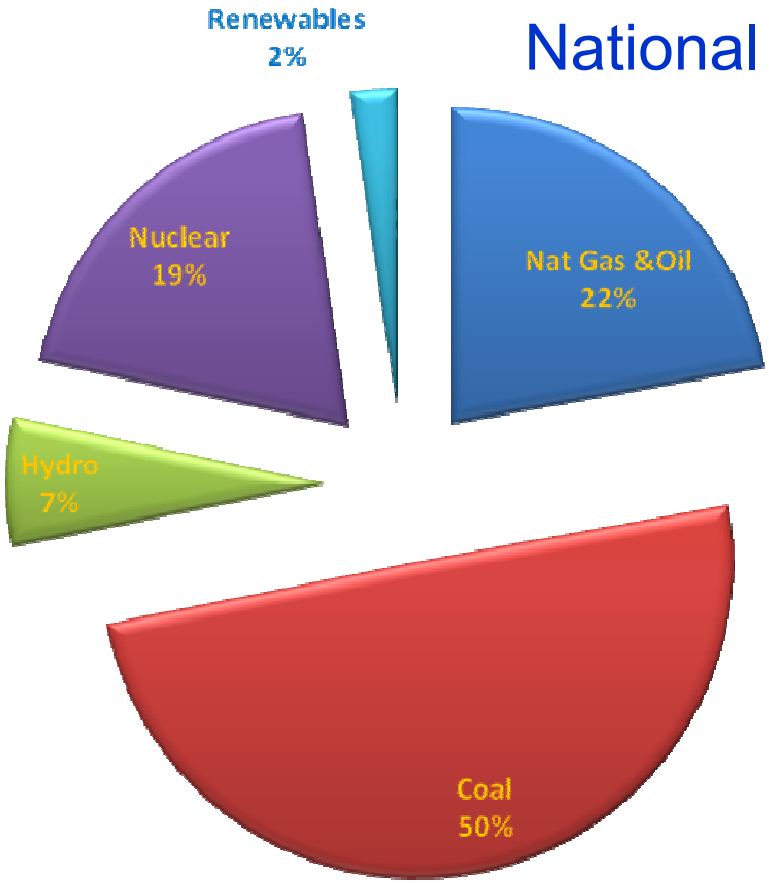
Electricity Sector



Generation Portfolio, 2005



California

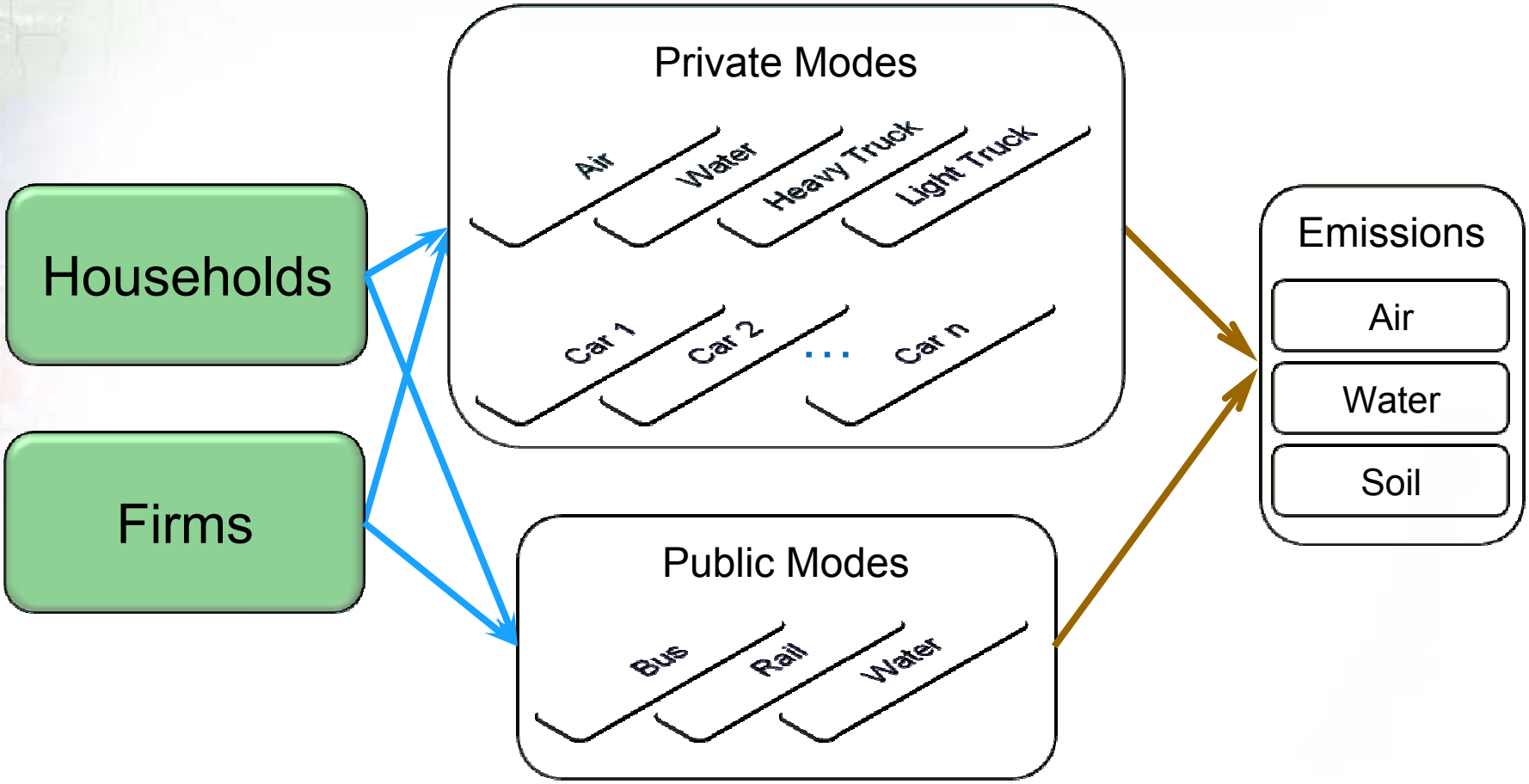


National

Transportation Demand

- The transport sector accounts for up to 48% of California C02 emissions
- To elucidate the path to our emission goals, patterns of vehicle use and adoption need to be better understood
- We are currently working to estimate demand systems that take explicit account of public/private modal choice and a larger universe of vehicle alternatives.

Transport Choice



Next Step: Mechanism Design

1. Recognition – which emissions?
    1. Legacy emissions
    2. Existing in-state emissions
    3. Embodied emissions
    4. Remote emissions
2. Coverage – who is included?
3. Allocation – property rights
4. Trading – mechanisms and incentives

How to Sustain Engagement

A three tier program:

1. A peer review process – independent buttress for official findings
2. Annual Climate Policy Workshop – sharing public goods
3. A granting/contract system - fostering R&D and innovation in data development, sector and policy research

Thank you